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TECHNICAL NOTES

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No. 596

FULL-SCALE WIND-TUNNEL AND FLIGHT TESTS OF A FAIRCHILD 22 AIRPLANE EQUIPPED WITH A ZAP FLAP AND ZAP AILERONS

By C. H. Dearborn and H. A. Soulé
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SUMMARY

A wing equipped with a Zap flap and Zap ailerons was tested on a Fairchild 22 airplane in the full-scale wind tunnel and in flight to determine the effect of the flaps and ailerons on the performance and the control characteristics of the airplane. The flaps were 0.30 of the wing chord and 0.83 of the wing span. Two sets of ailerons having equal areas but different proportions were tested, one set being 0.56 of the semispan and 0.18 of the chord and the other set being 0.46 of the semispan and 0.22 of the chord.

The wind-tunnel tests showed that, when the ailerons and horizontal tail surfaces were removed, the flaps increased the maximum lift coefficient from 1.48 to 2.39. In flight, the fully deflected flaps decreased the minimum speed from 48.2 to 38.8 miles per hour. The take-off and landing distances were both reduced by the flaps. The wind-tunnel tests showed the ailerons to increase the drag coefficient, at a lift coefficient and Reynolds Number corresponding to the high speed of the airplane, from 0.0432 to 0.0498 and 0.0514, the 0.46 semispan ailerons giving the highest drag. In the flight tests both sets of ailerons were found to give satisfactory rolling action in the normal-flight range. They required relatively large stick forces for their operation, however, and the variation of the forces with aileron deflection was not linear.

2.39
148
.91

INTRODUCTION

At the request of the Bureau of Aeronautics, Navy Department, the National Advisory Committee for Aeronautics is conducting a series of tests of different types of flapped wings on a Fairchild 22 airplane. The tests consist of the measurement in the full-scale wind tunnel of the primary aerodynamic characteristics of the airplane with each type of flap and, in flight, of the determination of the take-off, landing, and other characteristics not readily determined in the wind tunnel. The results from the Fowler-wing tests are given in reference 1. The present paper deals with the results of the tests of the Zap wing.

The Zap wing was fitted with both Zap flaps and Zap ailerons. The Zap flap is primarily a split flap but differs from conventional installations of flaps of this type in that its leading edge is moved aft along the lower surface of the wing as the flap angle is increased, so that the trailing edge of the flap remains approximately under the trailing edge of the wing. The Zap ailerons are small-chord airfoil surfaces fitted with leading-edge slats. They are mounted above and slightly forward of the trailing edge of the wing and are pivoted so that the angles of attack may be varied relative to the wing chord.

Although the Zap ailerons are usually employed in connection with Zap flaps, it is not essential that they be used together. In the present tests, therefore, the effects of the flaps and ailerons, wherever possible, were separately determined.

AIRPLANE AND WING

The Fairchild 22 airplane is a small externally braced monoplane equipped with a 32-foot 10-inch span, 5-foot 6-inch chord wing of N-22 airfoil section. The area of the wing is 171 square feet and it weighs approximately 200 pounds. The lateral control is provided by means of conventional ailerons of 12-inch (0.182c) chord extending across practically the entire trailing edge of the wing (0.83b).

The Zap wing (figs. 1 to 5 and table I) has the same plan form and airfoil section as the standard wing and was mounted on the Fairchild 22 fuselage with the same angle of wing setting and the same dihedral angle. It weighed 370 pounds, 170 pounds more than the standard wing. The flaps had a chord equal to 0.30c. They extended over the entire trailing edge of the wing with the exception of the rounded tips and a 3-foot cut-out over the pilot's cockpit, the span being equal to 0.83b. When fully deflected, the flaps made an angle of 59° to the wing chord and their leading edges were 0.80c back of the leading edge of the wing. Twenty-eight turns of the operating crank located in the cockpit were required to lower the flaps fully. The relation of the flap position and turns of the operating crank to the flap angle is given in figure 6.

Two sets of ailerons of Clark Y airfoil section having approximately the same area but differing in aspect ratio were provided for installation on the wing. Both were fitted with leading-edge slats having chords equal to 0.115 of the respective aileron chords. One set had the proportions of previous installations of Zap ailerons with a span of 0.56 b/2 and chord of 0.18c. As the previous installations had been unsatisfactory because the ailerons had appreciably lowered the high speeds of the airplanes to which they had been fitted, the second set of ailerons were made with a span of only 0.46 b/2 and a chord of 0.22c on the assumption that the aileron drag would be decreased with smaller aileron span.

In previous installations of the Zap ailerons, considerable difficulty had also been experienced in obtaining satisfactory stick forces. In order that stick forces could be investigated, if such an investigation were found advisable, means were provided for locating the aileron hinge axes for both sets of ailerons at 0.18, 0.20, and 0.22 of the respective aileron chords. The leading-edge slats were also adjustable as to position and angle. The aileron mechanism was arranged to operate the ailerons differentially, the maximum up deflection being 30° and the down deflection 15° from the neutral setting.

WIND-TUNNEL TESTS

Test Conditions

All wind-tunnel tests were made without the horizontal tail surfaces and propeller (fig. 5). The first tests determined the aerodynamic characteristics of the airplane with the flap set at 0°, 20°, 40°, 50°, and 59° and with no ailerons. The tests with the flap at 0° and 59° were repeated with both sets of ailerons. The 0.18c ailerons were tested both with and without slats, the 0.22c ailerons only with slats. These tests were made at a tunnel speed of approximately 57 miles per hour and covered an angle-of-attack range from -15° to 20°. Tests were then made over a speed range from 25 to 80 miles per hour to determine the scale effect on the maximum lift coefficient for the flap-up and flap-down positions with no ailerons. The scale effect on the minimum drag coefficient was investigated over a speed range from 30 to 120 miles per hour with the flap up, with the ailerons removed, and with the three aforementioned aileron arrangements.

Results and Discussion

The results have been corrected for wind-tunnel effects and are presented in curve form in figures 7 to 13. The curves of lift, drag, and pitching-moment coefficients plotted against angle of attack are shown in figures 7, 8, and 9, as determined from tests at an air-stream velocity of approximately 57 miles per hour. Figure 10 presents a portion of the data replotted in the form of polars. The results of the scale-effect tests are presented in figures 11, 12, and 13.

The lift curves (fig. 7) for the various flap settings investigated show normal variations with flap position in that as the flap was lowered the angle of zero lift occurred at larger negative angles of attack, the slope of the curves remains essentially constant, and the stall occurred at approximately the same angle of attack. With the flaps up the peak of the lift curve is well defined and fairly smooth, but with flaps down the curves show a consistent "hysteresis" effect as the angle of attack was increased beyond the stall and then reduced. Apparently the wing was unable to reestablish smooth flow conditions after the burble had once set in and the angle of attack was reduced 2° or 3° below that at which the wing originally stalled. This phenomenon results in a system of double peaks in the lift curves and gives two possible values for the maximum lift coefficient. These values of $C_{L_{max}}$ for the various flap settings are tabulated below.

Flap deflection	$C_{L_{max}}$	
degrees	α_T increasing	α_T decreasing
0	1.48	1.48
20	1.96	1.89
40	2.28	2.21
50	2.37	2.28
59	2.39	2.27

The curves of lift, drag, and pitching-moment coefficients plotted against angle of attack are shown in figures 8 and 9 for the airplane as tested with the 0.18c and 0.22c ailerons. A comparison between the curves on these figures and those of figure 7 indicates the effect of the ailerons on the aerodynamic characteristics of the airplane. In general, the installation of the Zap ailerons decreased the lift of the airplane and increased the drag. This result is illustrated more clearly by the polars shown in figure 10 for the airplane with and without the 0.18c ailerons. It is evident from these polars that the ailerons would have a marked adverse effect on the performance of the airplane.

The effect of the neutral setting of the aileron on the characteristics of the airplane was investigated in preliminary tests in which the 0.18c ailerons were tested at several angles from 0° to 6° to the wing chord. The results of these tests are not shown by separate curves as it was found that, irrespective of aileron setting within this range, the polars of the airplane were identical with that shown in figure 10 for the 0.18c ailerons set at 3°.

Figure 11 shows the scale effect on the minimum drag coefficient of the airplane for four conditions: ailerons off, 0.18c ailerons with slats, 0.18c ailerons without slats, and 0.22c ailerons with slats. As preliminary computations had shown that the high speed of the airplane would correspond to a lift coefficient of approximately 0.3, figure 12, showing the scale effect on the drag coefficient at this lift coefficient, has been prepared and included. The curves for the airplane without the ailerons are very smooth. The corresponding curves for the different aileron conditions, however, are much less consistent and show some scattering of individual points, which would indicate that the ailerons and their supports produce relatively large and unstable interference effects. The following table gives the minimum drag coefficient and the drag coefficient at a lift coefficient of 0.3 for the various aileron conditions at an air speed of 100 miles per hour. In addition, the increase in drag resulting from the ailerons is tabulated as a percentage of the minimum drag of the airplane without ailerons and as a percentage of the estimated drag coefficients for the wing alone.

Aileron condition	$C_{D_{min}}$	$\Delta C_{D_{min}}$	$\frac{\Delta C_{D_{min}}}{C_{D_{min}}*}$ *(with no ailerons) percent	$\frac{\Delta C_{D_{min}}}{C_{D_{min}}*}$ *(for wing alone estimated) percent	C_D at C_L 0.3	ΔC_D at C_L 0.3	$\frac{\Delta C_D}{C_D*}$ *(with no ailerons) at C_L 0.3 percent
No ailerons	0.0411	-	-	-	0.0432	-	-
0.18c aileron, slat off	.0460	0.0049	11.9	57.6	.0488	0.0056	13.0
0.18c aileron, slat on	.0473	.0062	15.1	73.0	.0498	.0066	15.3
0.22c aileron, slat on	.0484	.0073	17.8	86.0	.0514	.0082	19.0

The table shows that for a lift coefficient of 0.3 the increase in drag resulting from addition of the ailerons was considerably greater than for the minimum-drag condition; also, that the ailerons with the shorter span gave the greater drag.

Curves of maximum lift coefficient plotted against Reynolds Number are shown in figure 13 for the Fairchild 22 airplane with the flaps up and down. The curves show that the scale effect on maximum lift coefficient was less with the flap down than with the flap up.

Performance Computations

Figures 14 and 15 illustrate the effect of the Zap flap and ailerons on the performance of the airplane. They present velocity diagrams and horsepower curves, respectively, and are based on the data from the full-scale wind tunnel. It should be appreciated that, although they show the effect of the flap and ailerons on the performance of the airplane, they do not accurately represent the true performance because, in particular, the horizontal tail surfaces were not in place during the tunnel tests and the horsepower-available curve used is only approximate.

Computed gliding characteristics.- The effect of the Zap flap and ailerons on the gliding characteristics of the airplane is shown by the lower curves of the velocity diagram (fig. 14). The principal items of performance as shown by the curves are given in the following table. Comparative data for the airplane fitted with an N.A.C.A. CYH wing, which have already been used as a basis for comparison in reference 1, are also given in the table. Under "Equal disposable load," allowance has been made for the greater weight of the wing fitted with the Zap flap and ailerons.

Wing	Weight	Minimum speed		Minimum gliding angle	Gliding angle at minimum speed		Horizontal distance traveled during 100-foot descent	
		Flap up	Flap down		Flap up	Flap down	Maximum	Minimum
	lb.	m.p.h.	m.p.h.	deg.	deg.	deg.	ft.	ft.
Zap No ailerons	1,600	49.3	38.4	5.6	7.4	13.7	1,020	410
0.22c ailerons	1,600	49.9	39.5	5.9	7.7	13.9	967	410
N.A.C.A. CYH Equal gross weight	1,600	50.6	-	5.4	7.4	-	1,058	770
Equal disposable load	1,430	48.0	-	5.4	7.4	-	1,058	777

The tabulated values show that the minimum speed and minimum gliding angle of the airplane with Zap flaps down were slightly increased by the installation of the ailerons. As compared with the N.A.C.A. CYH wing, the Zap flap, despite the increased wing weight, gave a decrease of 8.5 miles per hour for the minimum speed. With the Zap flap a possible variation of the gliding angle of 8.1° was obtained from the maximum L/D to the stall, as compared with 2° for the N.A.C.A. CYH wing.

Computed power-on characteristics.- The results of the computations for power-on flight are illustrated by the upper curves of figure 14 and by figure 15. The complete power-required curves of figure 15 and the curves of figure 14 were computed on the basis of wind-tunnel data for a test velocity of 57 miles per hour. The portions of the power-required curves for a test velocity of 105 miles per hour are given in figure 15.

The principal items of the power-on performance as shown by the figures including similar data for the N.A.C.A. CYH wing are given in the following table.

Wing	Weight lb.	Maximum rate of climb ft. per min.	High speed (test velocity = 105 m.p.h.) m.p.h.
Zap (flap up)			
No ailerons	1,600	580	113.8
0.22c ailerons	1,600	537	104.2
N.A.C.A. CYH			
Equal gross weight	1,600	594	110.6
Equal disposable load	1,430	715	114.9

The table shows that the Zap flap had very little effect on the power-on performance as compared with the N.A.C.A. CYH wing, except for the climb with the lighter weight. The increased weight accompanying the installation of the flap and ailerons accounted for a reduction in the maximum rate of climb by approximately 135 feet per minute and the maximum angle of climb by 1.6°. The Zap ailerons, however, had considerable adverse effect on the performance, the high speed in particular being reduced from 113.8 to 104.2 miles per hour. If constant available horsepower as could be obtained with a propeller especially suited to the Zap wing installation is assumed, the high speed with the Zap ailerons would be increased from 104.2 to 106.2 miles per hour.

FLIGHT TESTS

The flight tests consisted of preliminary flights to obtain satisfactory arrangements of the ailerons for the rest of the tests; the measurement of the aileron characteristics for the arrangements found; and the determination of the effect of the flap on the low speed of the airplane, the take-off and landing run, and the longitudinal stability and control characteristics. Aileron effectiveness was determined by measurement of the maximum angular acceleration and rate of roll that could be obtained with the ailerons. The low speed of the airplane was measured by an air-speed recorder that had previously been calibrated against the suspended pitot head. The take-off and landing runs were measured by means of the method described in reference 2, involving the use of a phototheodolite. The effect of the flap on the longitudinal stability and control characteristics was determined by pilots' observations. The flap-operating force was measured by a spring balance attached to the flap-operating crank. For the tests of the flaps, the 0.22c ailerons were installed on the airplane.

Tests with Zap Ailerons

Preliminary flights.- As the reduction of aileron span was shown by the wind-tunnel tests to have an adverse effect on the aileron drag, it was evident that the ailerons need further development if their drag is to be reduced. For this reason a complete investigation of the stick forces utilizing all the adjustments available was not considered warranted at the present time. In the preliminary flights, an attempt was made only to obtain stick forces sufficiently satisfactory for comparison of the effectiveness of the two sets of ailerons and for the flap tests. The aileron leading-edge slats were placed in a position (fig. 2) as closely as possible to that found most satisfactory by the Zap Development Corporation in previous tests on an Aristocrat airplane. The 0.18c ailerons were hinged at $0.18c_a$. With this aileron arrangement the stick forces were fairly large in the high-speed range but, in the slow-speed range with the flap down, the forces were so small that the stick would not return completely to neutral after being fully displaced. These ailerons were not tested with the $0.20c_a$ and $0.22c_a$ hinge positions. The 0.22c ailerons were tested with the hinge axis located at $0.18c_a$ and $0.20c_a$. With the $0.18c_a$ position of the hinge axis, the control forces were too heavy throughout the entire speed range. With $0.20c_a$ location of the hinge axis the 0.22c ailerons had approximately the same variation of stick force as did the 0.18c ailerons hinged at $0.18c_a$. With both sets of ailerons, in addition to being too heavy for comfortable operation at high speed, the forces did not vary progressively with deflection. The forces rapidly increased with small deflections, then decreased over a small portion of the range, and increased again as maximum deflection was approached.

<u>Lateral-control effectiveness</u>.- The lateral-control effectiveness, as indicated by the maximum angular accelerations and velocities in roll that could be obtained with the ailerons at various air speeds with the flap up and down, was determined for each set of ailerons. The arrangement of the ailerons for the tests is given in figure 2. The results are given in figures 16 and 17, along with similar results obtained with the standard Fairchild 22 ailerons (reference 3). Both sets of Zap ailerons had approximately the same effectiveness, the 0.18c ailerons giving slightly greater rolling accelerations and the 0.22c ailerons the greater rolling velocity. The aileron effectiveness was increased at a given air speed by lowering the flaps. At the stall with the flaps down the ailerons were as effective as at the stall with the flaps up, despite the lower speed. The Zap ailerons were appreciably more effective than the standard ailerons for the airplane.

The rolling-moment coefficients derived from the measured rolling accelerations and velocities and from the moment of inertia about the longitudinal axis obtained by the method described in reference 3 are given in figure 18. Comparative data on the standard ailerons are included. The rolling-moment coefficients are approximately equal for the two sizes of Zap ailerons and are about twice those for the standard ailerons. The fact that the difference in the rolling accelerations between the Zap and standard ailerons is small results from the different moments of inertia of the wings on which they were tested, the moment of inertia of the Zap wing being almost twice that of the standard wing. Part of the difference in the moments of inertia is attributable to the flap and part to the Zap ailerons themselves. If the tests had been made with comparable wing construction, i.e., with a wing without flap, the rolling accelerations of the Zap ailerons would have been greater relative to those for standard ailerons than shown in figures 16 and 17 but not so much greater as would be indicated by the difference in the rolling-moment coefficients. The maximum rolling velocities would be only slightly affected.

The control above the stalling angle and the yawing characteristics were obtained from observations by the pilots. They reported that the Zap ailerons gave very little, if any, control above the stall and that the yawing action due to the ailerons was adverse and of the magnitude of that for the standard ailerons.

Lateral-control force.- The stick forces required for abrupt full deflection of the ailerons were recorded at two air speeds, one in the low-speed range where the forces were satisfactory and one in the high-speed range where the forces were considered heavy. The data are given in the following table:

	0.22c ailerons		0.18c ailerons	
	V m.p.h.	Control force lb.	V m.p.h.	Control force lb.
Flaps up	50	5.8	52.5	4.0
	-	-	98.7	14.6
Flaps down	42.2	4.8	40.6	3.1
	73.5	13.7	74.6	9.0

Tests with Zap Flap

Minimum speed.- The minimum speeds of the airplane with the Zap flap up and down were determined because the values of maximum lift coefficient given by the tunnel tests did not correspond to those for the airplane as flown. The horizontal tail surfaces were not in place during the tunnel measurements and, prior to the flight tests, it was found necessary to taper the inboard ends of the flap (fig. 1) to reduce vibration of the horizontal tail surfaces. The flight data for the two flap conditions are tabulated below:

[Propeller stopped in vertical position. Weight, 1,600 lb.]

	V_{min} m.p.h.	$C_{L_{max}}$
Flap up	48.2	1.55
Flap down	38.8	2.34

As was the case with the Fowler wing (reference 1) the maximum lift coefficients obtained in flight for the Zap wing were appreciably greater than those obtained in the full-scale tunnel. A comparison of the flight and wind-tunnel values follows:

	$C_{L_{max}}$	
	Flap up	Flap down
Flight	1.55	2.34
Full-scale tunnel (no horizontal tail)	1.49	2.27
Full-scale tunnel (tail correction applied)	1.42	2.14

An investigation to determine the cause of the discrepancy is being made. Preliminary results of this investigation indicated that at least a part of the discrepancy was caused by the fact that in flight the maximum lift was obtained by slowly increasing the angle of attack until the stall is reached, whereas the wind-tunnel measurements were made with the airplane stationary.

Take-off characteristics.- Figure 19 gives the effect of flap position on the take-off ground run and distance required to attain an altitude of 50 feet. Prior to the take-off tests, flights were made to determine the reading of the pilot's air-speed indicator at the stall with full throttle for each flap position. In the take-off runs the tail skid was raised off the ground as soon as possible. During the acceleration run, the fuselage was held approximately horizontal until a speed 2 or 3 miles per hour in excess of the stalling speed was reached. The pilot then pulled the airplane off the ground and maintained as closely as possible the take-off speed until he attained an altitude of 50 feet.

Figure 19 shows that the flaps produced a considerable decrease in both the ground run and the distance required to clear the ground by 50 feet. It should be noted that the flap position for the shortest take-off run was critical. The minimum ground run occurred with the flap down approximately 24°. With this setting the run was 365 feet as compared with 475 feet with the flap up. The run required from the start to clear the ground by 50 feet was shortest with the flap down approximately 20°. With this setting the take-off run was 715 feet as compared with 1,025 feet with the flap up. The airplane was incapable of taking off when the flap was down its full extent, a fact to be expected from observation of figure 15.

Landing characteristics.- The Zap wing was investigated for normal braked landings, which is the type of landing a pilot would make after he had become familiar with the handling characteristics of the airplane. In the landings, the distance traveled in the air from an altitude of 50 feet to ground contact and the ground run were separately measured. Landings were made with flap up and flap down and the results of these landings are given in figures 20 and 21. With the flap up the minimum landing run was 1,071 feet, of which 672 feet were air run and 399 feet, ground run. The minimum air run and the minimum ground run, with the flap fully down, were each 243 feet. From these results it can be seen that the air run was reduced 64 percent and the ground run 39 percent by the use of the flap. The total reduction in landing run was 585 feet, or 54.5 percent.

Flap control force.- The force required on the crank to operate the Zap flap was practically constant for the full range of deflection and averaged approximately 3 pounds. It varied slightly with speed but, up to a speed of 70 miles per hour, did not exceed 4 pounds. The force applied to the leading edge of the flap parallel to the slide was 43 times the force on the crank. Past experience has shown that the control force could be about twice as great and still be considered satisfactory. For this reason it is concluded that the gear ratio in the Zap flap-retracting mechanism could be changed to permit the flap to be raised and lowered with half the present number of turns of the operating crank without increasing the operating force to an unsatisfactory value.

<u>Effect of the flap on the longitudinal-control characteristics</u>.- The Zap flap as originally installed caused considerable buffeting of the horizontal tail surfaces. Observations made during the tunnel tests showed that a series of vortices with axes parallel to the wing span were shed by the trailing edge of the flap and impinged directly on the stabilizer. The buffeting was eliminated by tapering the inboard ends of the flap from points outboard of the tail-surface span (fig. 1). The large stabilizer developed in connection with the Fowler tests of reference 1 was used with the Zap wing. No difficulty was experienced with the longitudinal stability or control characteristics, although lowering the flaps tended to make the airplane balance at a lower angle of attack for a given stabilizer setting.

CONCLUSIONS

1. The Zap flaps increased the maximum lift coefficients of the airplane without the ailerons or the horizontal tail surfaces from 1.48 to 2.39.

2. The measured minimum speed of the Fairchild 22 airplane was reduced from 48.2 to 38.8 miles per hour by full deflection of the flaps.

3. The landing run from an altitude of 50 feet was reduced from 1,071 to 486 feet.

4. The flaps reduced the distance required to take off and attain an altitude of 50 feet from 1,025 to 715 feet, the minimum distance being attained with approximately one-third flap deflection.

5. The Zap ailerons were shown by the wind-tunnel tests to cause a large increase in the drag of the airplane, at a lift coefficient and Reynolds Number corresponding to high speed, the 0.22c ailerons increasing the drag coefficient from 0.0432 to 0.0514. Computations showed that this drag increase will reduce the high speed of this airplane from 113.8 to 104.2 miles per hour.

6. The shorter-span ailerons produced a slightly greater drag than the larger ones.

7. The flight tests showed that the Zap ailerons

gave satisfactory rolling action throughout the normal-flight range but gave very little, if any, control above the stall.

8. The stick forces required for the operation of the ailerons were too high for an airplane of the size of the Fairchild 22 airplane. Also, the variation of stick force with deflection is irregular and not linear, as would be desirable.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., March 4, 1937.

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2. Thompson, F. L., Peck, W. C., and Beard, A. P.: Air Conditions Close to the Ground and the Effect on Airplane Landings. T.R. No. 489, N.A.C.A., 1934.

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TABLE I

CHARACTERISTICS OF FAIRCHILD 22 AIRPLANE

WITH A ZAP FLAP AND ZAP AILERONS

Wing:

Area, S	171 sq.ft.
Span, b	32 ft. 10 in.
Chord of basic airfoil, c	5 ft. 6 in.
Aspect ratio	6.3
Airfoil section	N-22
Angle of wing setting	1°
Dihedral	1°

Zap flap:

Total area	40.8 sq.ft.
Span, b_f	13 ft. 6 in.
Chord, c_f	19.7 in.
Maximum deflection	59°

Ailerons:

	0.18c	0.22c
Area (each)	8.75 sq.ft.	8.85 sq.ft.
Span (each)	8 ft. 10.3 in.	7 ft. 4 in.
Chord, c_a	12 in.	14.625 in.
Balance	4.2 in.	4.7 in.

Neutral setting (relative to wing chord)	Up 3°
Deflection from neutral	Up 30° Down 15°

TABLE I (Continued)

Stabilizer:	
Area	27 sq.ft.
Span	10 ft.
Deflection (relative to thrust axis)	Up to 4.1° Down 2.5°
Elevator:	
Area	10.4 sq.ft.
Deflection (relative to thrust axis)	Up 28° Down 27°
Distance from L.E. of wing to elevator hinge	14 ft. 3 in. or 2.59c
Fin:	
Area	4.1 sq.ft.
Rudder:	
Area	6 sq.ft.
Deflection	Right 20° Left 20°
Weight data:	
Weight	1,574 to 1,600 lb.
c.g. position:	
Aft L.E. of wing	18-1/8 in. 27.5 percent c
Below thrust axis	5/8 in.
Moment of inertia about longitudinal axis	1,182 slug-ft.[a]
Engine:	
Four-cylinder inverted air-cooled Cirrus	
Rated horsepower	95 at 2,100 r.p.m.

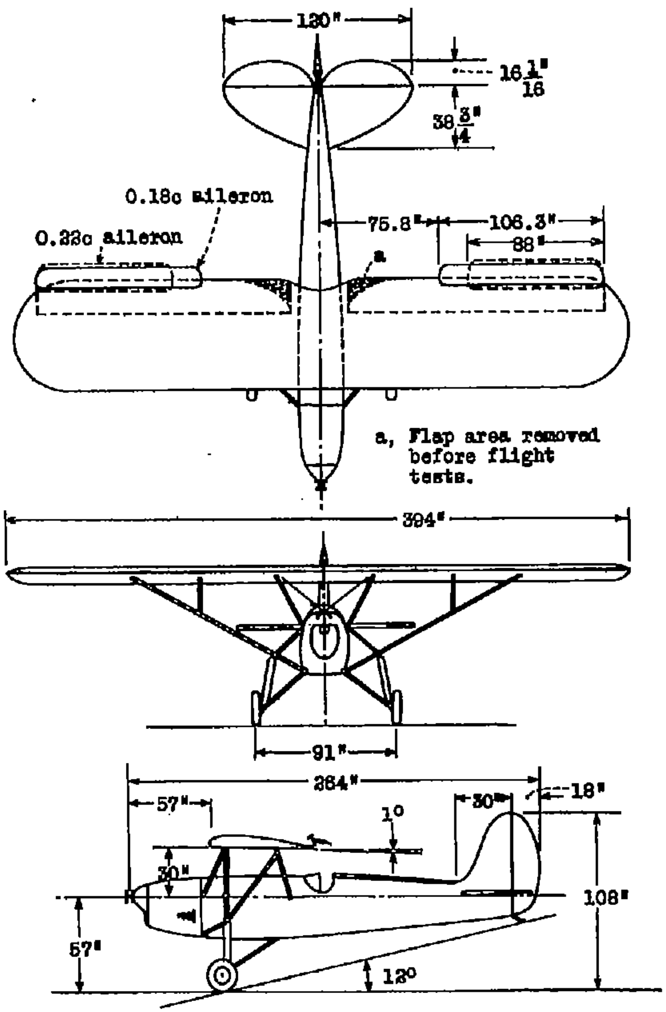


Figure 1.- Three-view drawing of Zap wing installation on Fairchild 22 airplane.

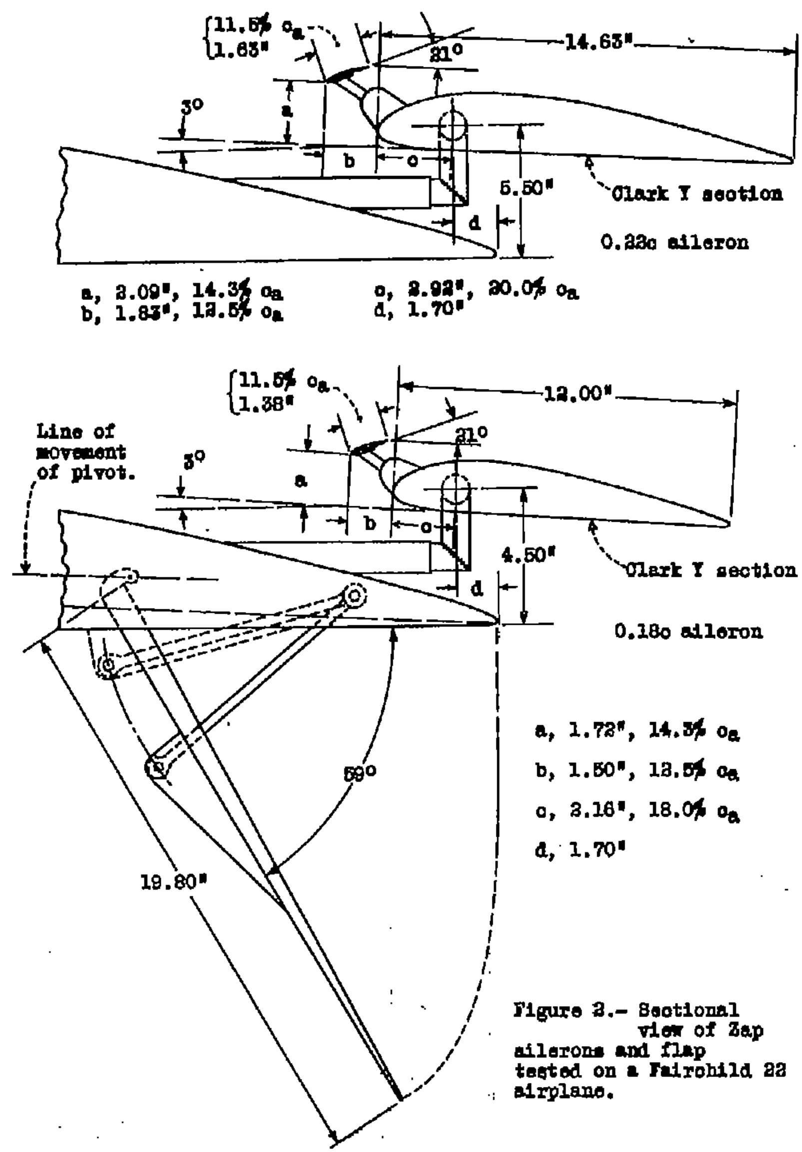


Figure 2.- Sectional view of Zap ailerons and flap tested on a Fairchild 22 airplane.

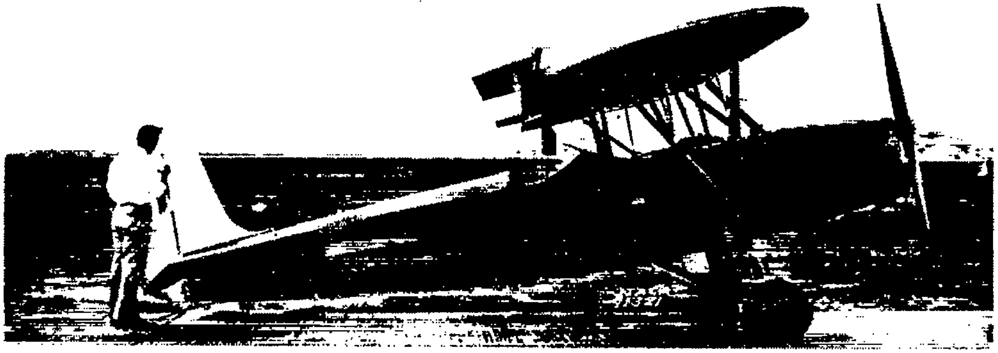


Figure 3.- Fairchild 22 airplane with Zap flaps in the up position.

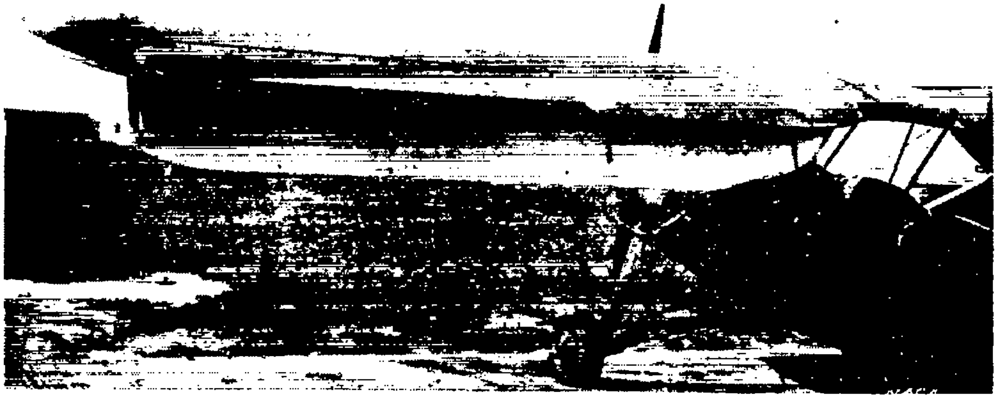


Figure 4.- Fairchild 22 airplane with Zap flaps in the down position.

Figure 5.- Fairchild 22 airplane with Zap wing mounted in the full-scale wind tunnel.

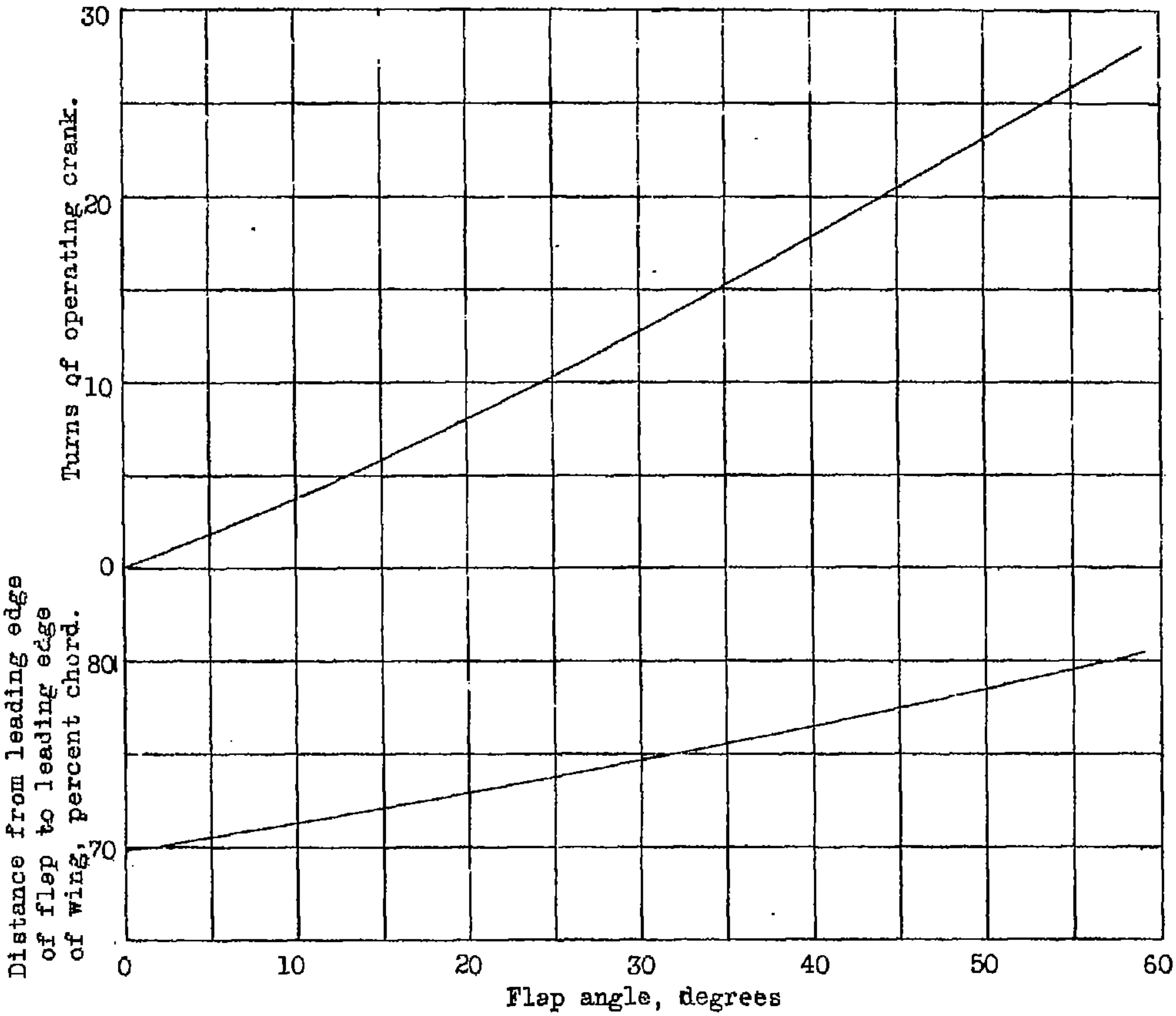


Figure 6.- Relation of flap position and turns of operating crank to flap angle for Zap wing on Fairchild 22 airplane.

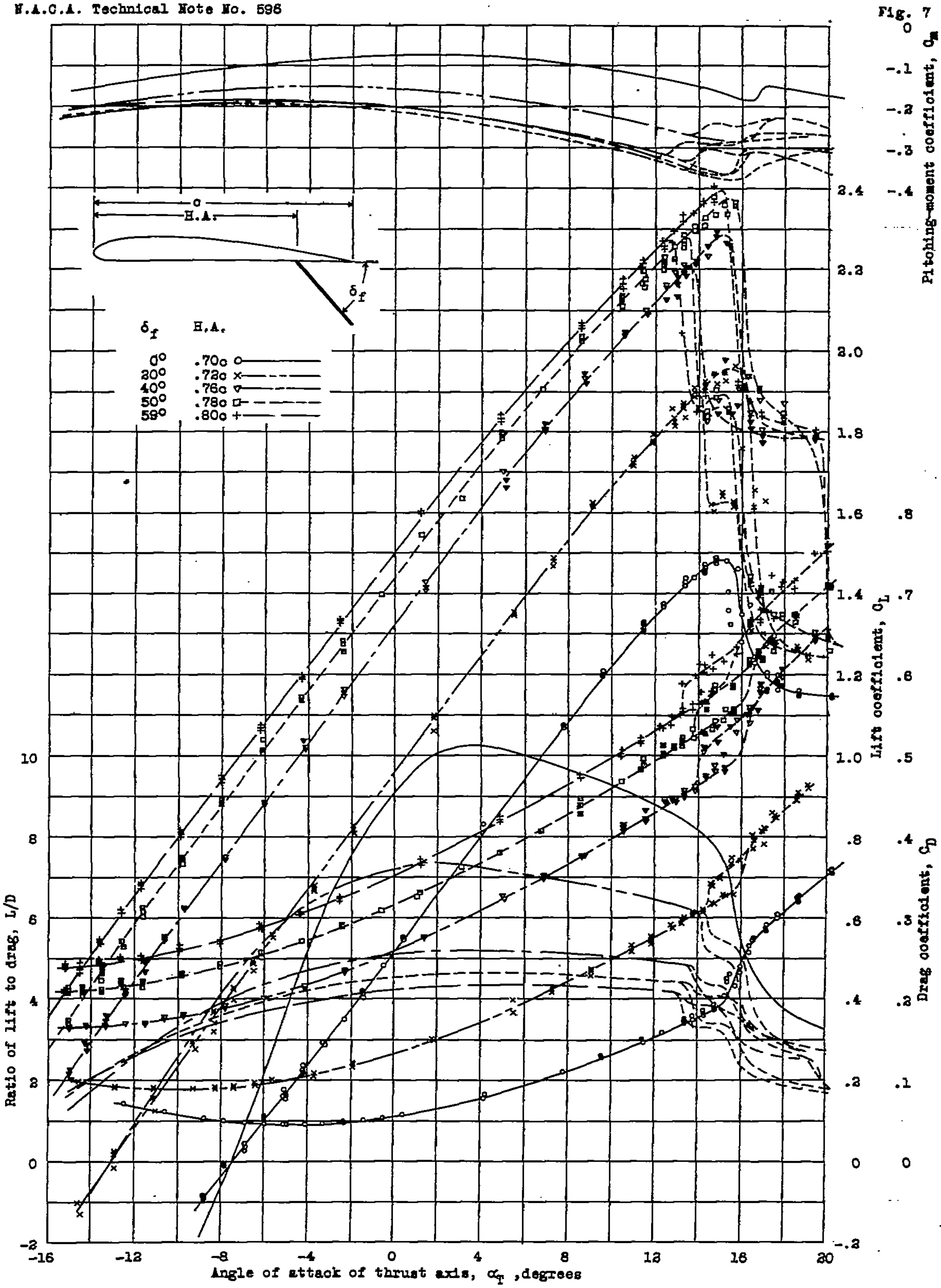


Figure 7.- Aerodynamic characteristics of Fairchild 22 airplane with 0.30c Zap flaps. Ailerons, propeller, and horizontal tail surfaces removed; results corrected for wind-tunnel effects; test velocity, approximately 57 m. p. h.

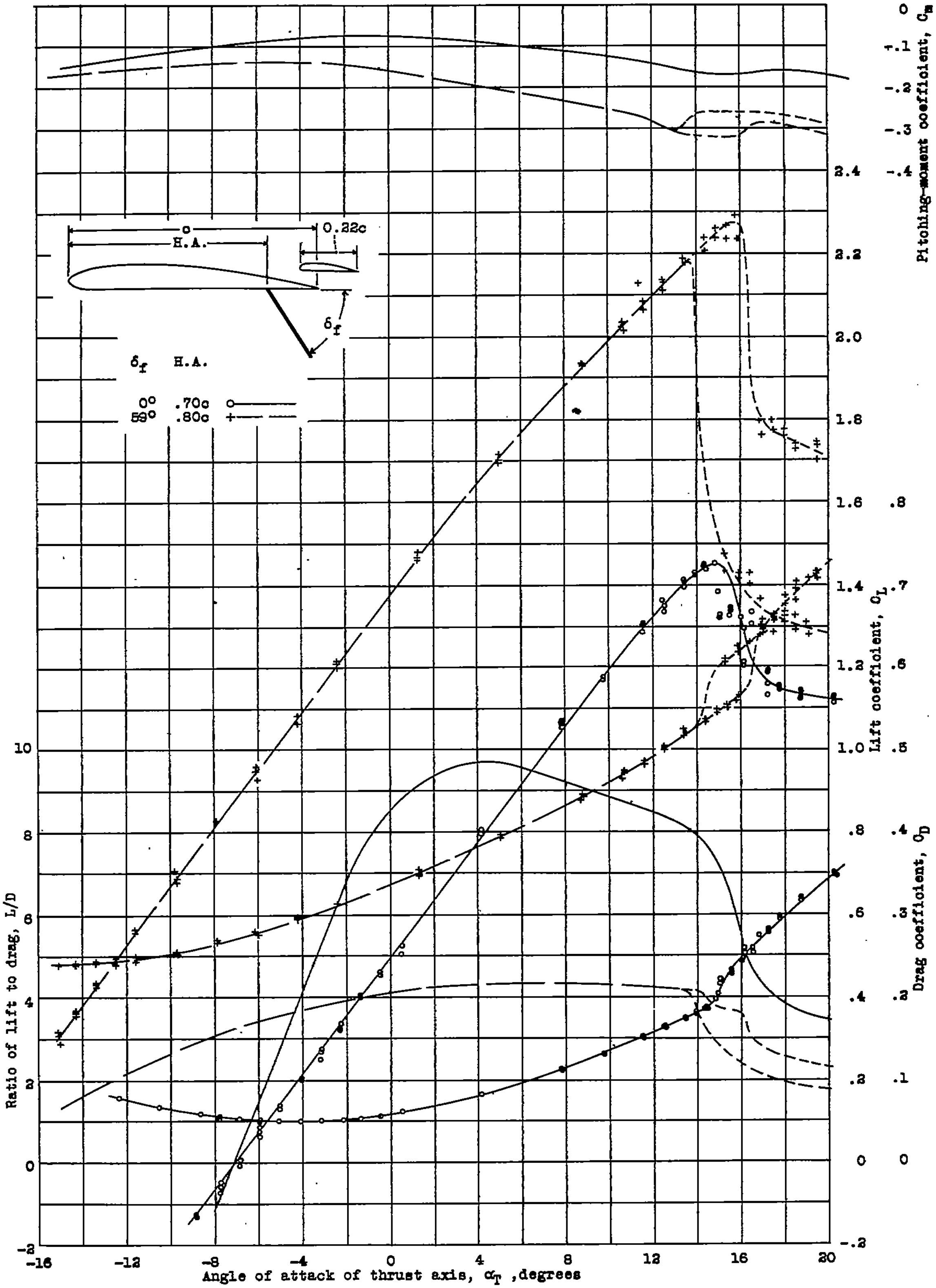


Figure 8.- Aerodynamic characteristics of Fairchild 22 airplane with 0.30c Zap flaps and 0.18c Zap ailerons. Ailerons set 3° relative to the wing chord; propeller and horizontal tail surfaces removed; results corrected for wind-tunnel effects; test velocity, approximately 57 m. p. h.

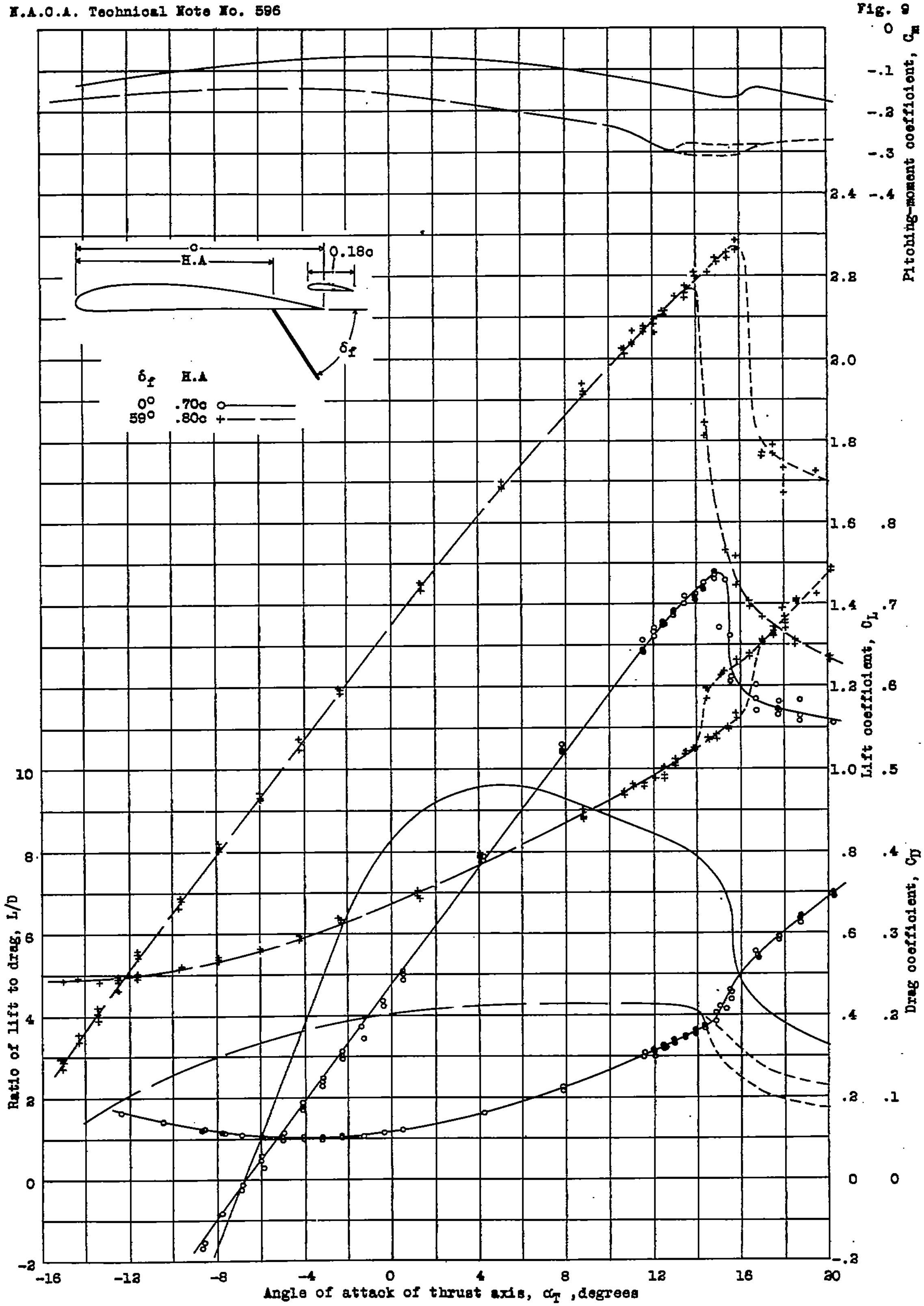


Figure 9.- Aerodynamic characteristics of Fairchild 22 airplane with 0.30c Zap flaps and 0.22c Zap ailerons. Ailerons set 3° relative to the wing chord; propeller and horizontal tail surfaces removed; results corrected for wind-tunnel effects; test velocity, approximately 57 m. p. h.

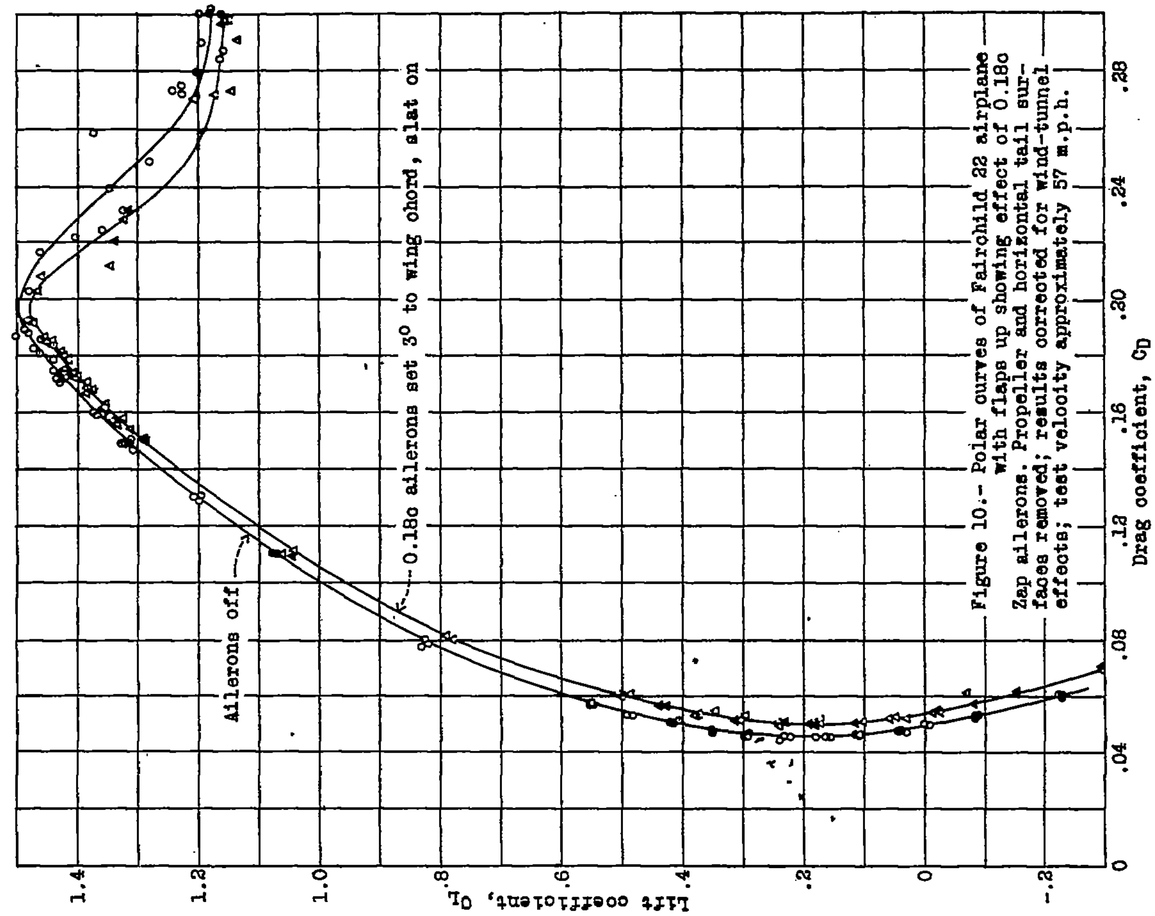


Figure 10.- Polar curves of Fairchild 22 airplane with flaps up showing effect of 0.18c Zap ailerons. Propeller and horizontal tail surfaces removed; results corrected for wind-tunnel effects; test velocity approximately 57 m.p.h.

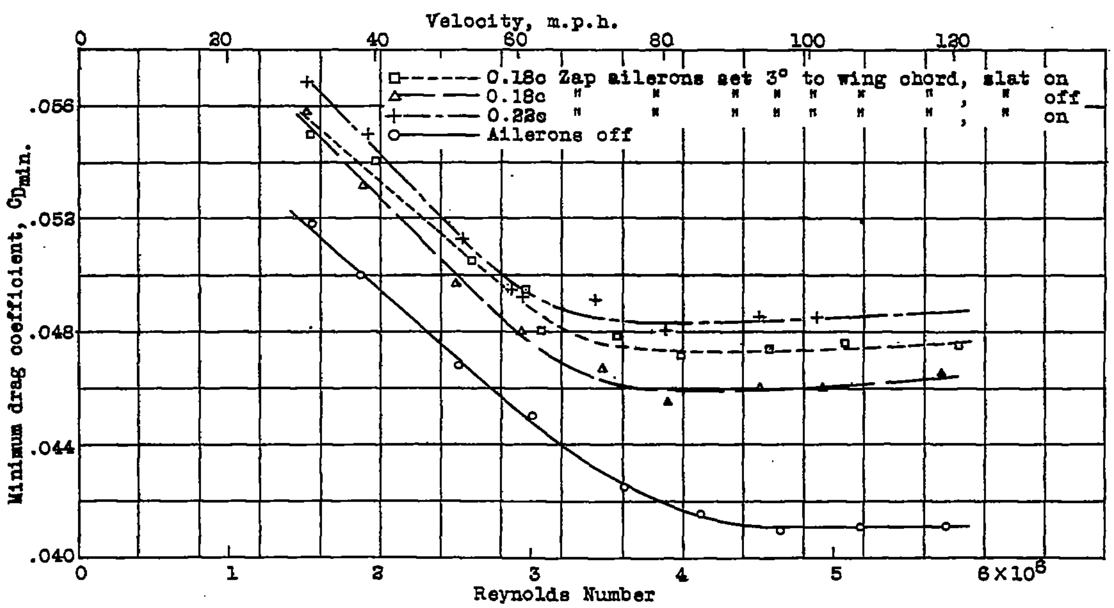


Figure 11.- Scale effect on the minimum drag coefficient of the Fairchild 22 airplane with flaps up. Propeller and horizontal tail surfaces removed; results corrected for wind-tunnel effects.

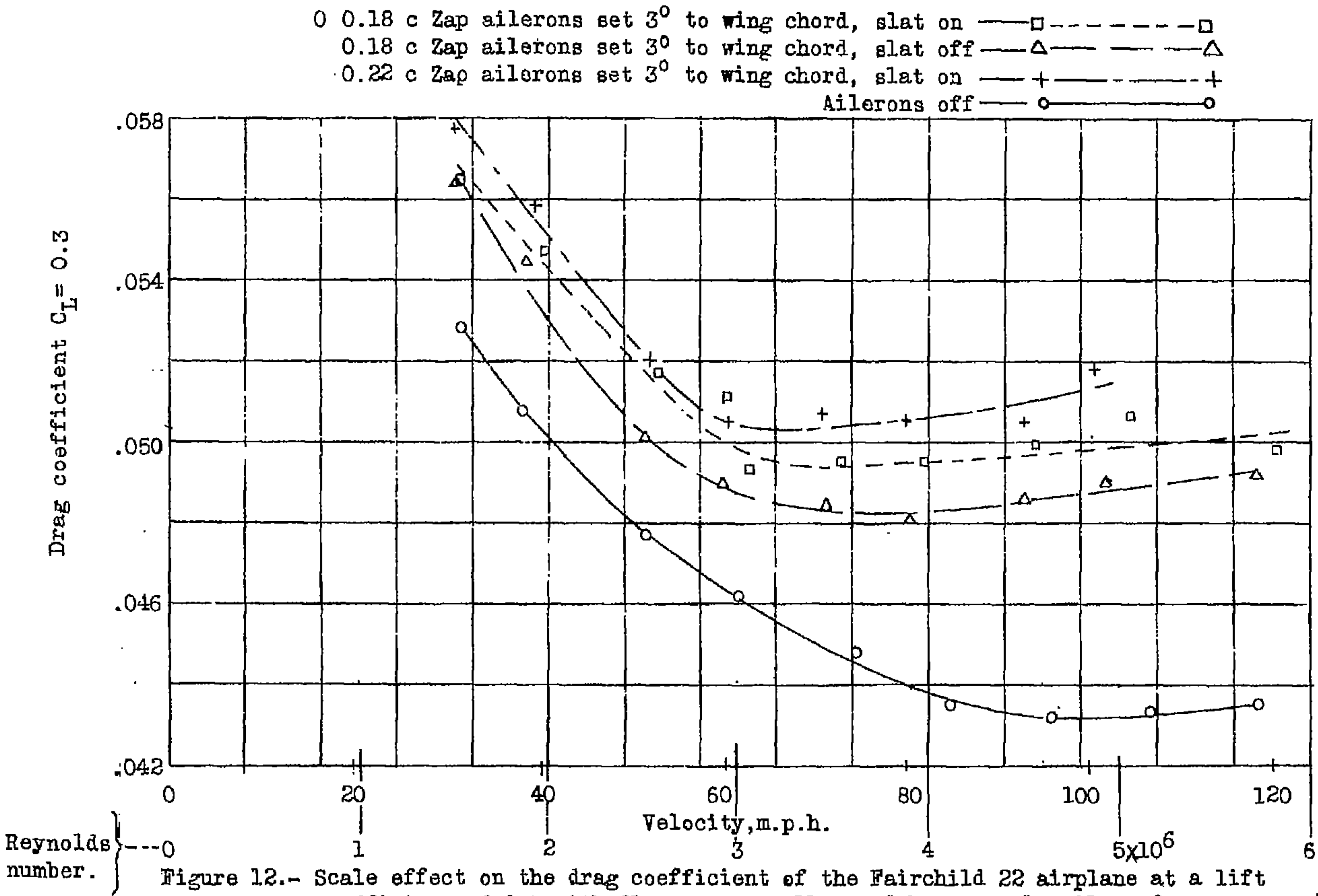


Figure 12.- Scale effect on the drag coefficient of the Fairchild 22 airplane at a lift coefficient of 0.3 with flaps up. Propeller and horizontal tail surfaces removed, results corrected for wind-tunnel effects.

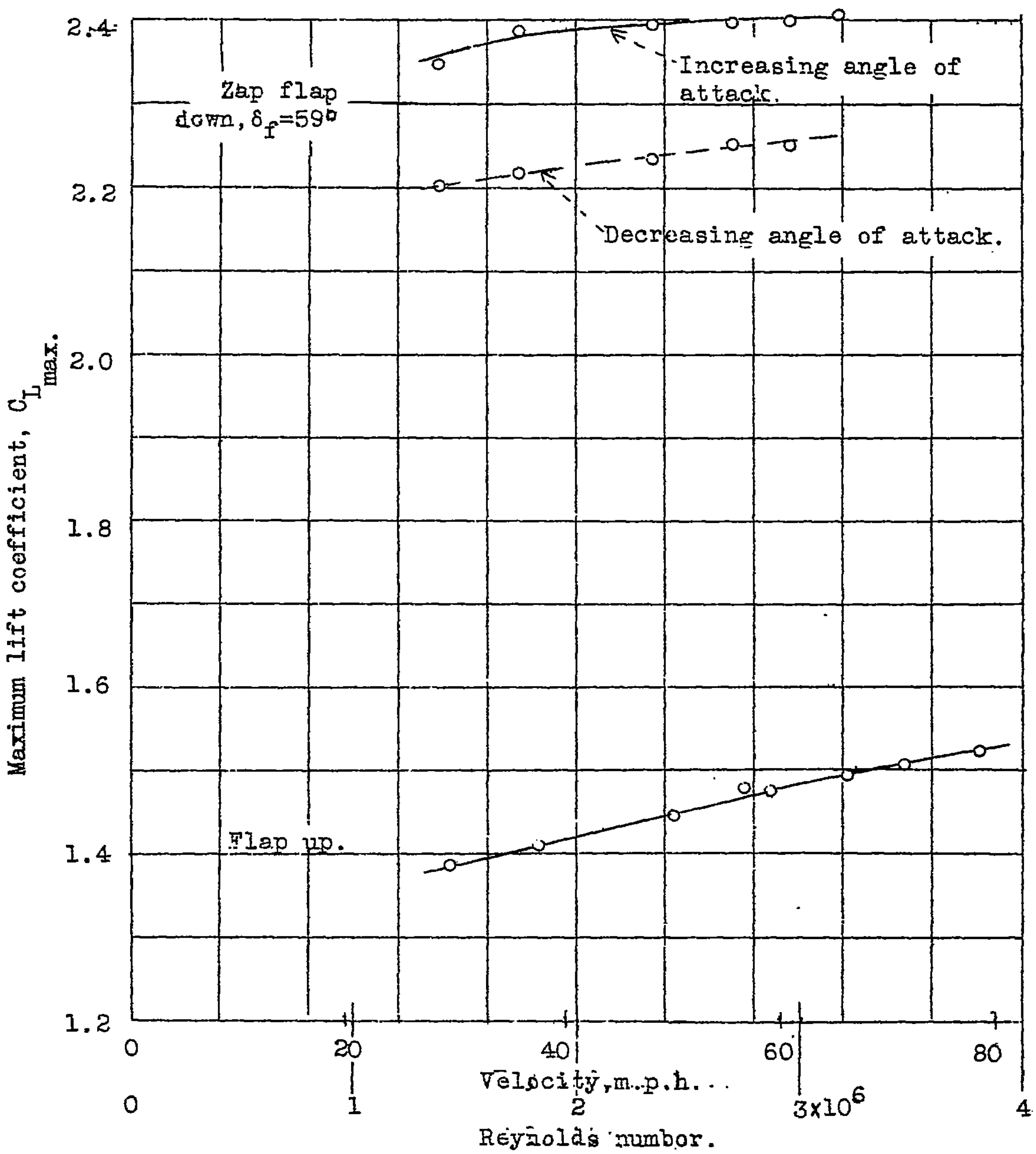


Figure 13.- Scale effect on the maximum lift coefficient of the Fairchild 22 airplane. Ailerons, propeller, and horizontal tail surfaces removed; results corrected for wind-tunnel effects.

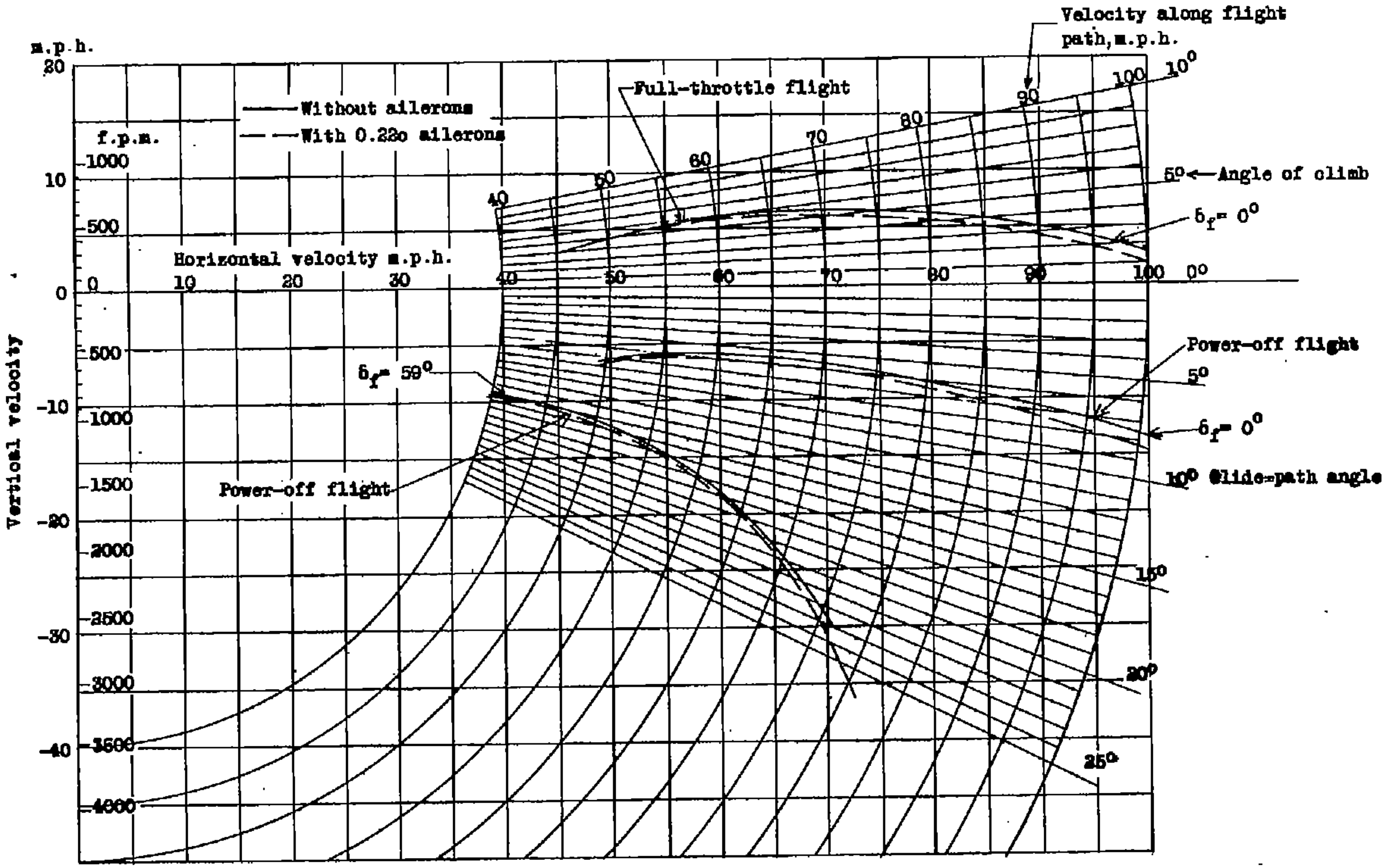


Figure 14.- Velocity diagram for Fairchild 22 airplane with Zap wing. From full-scale wind-tunnel data; wind velocity, 57 m.p.h.; weight, 1600 lb.; wing area, 171 sq.ft.

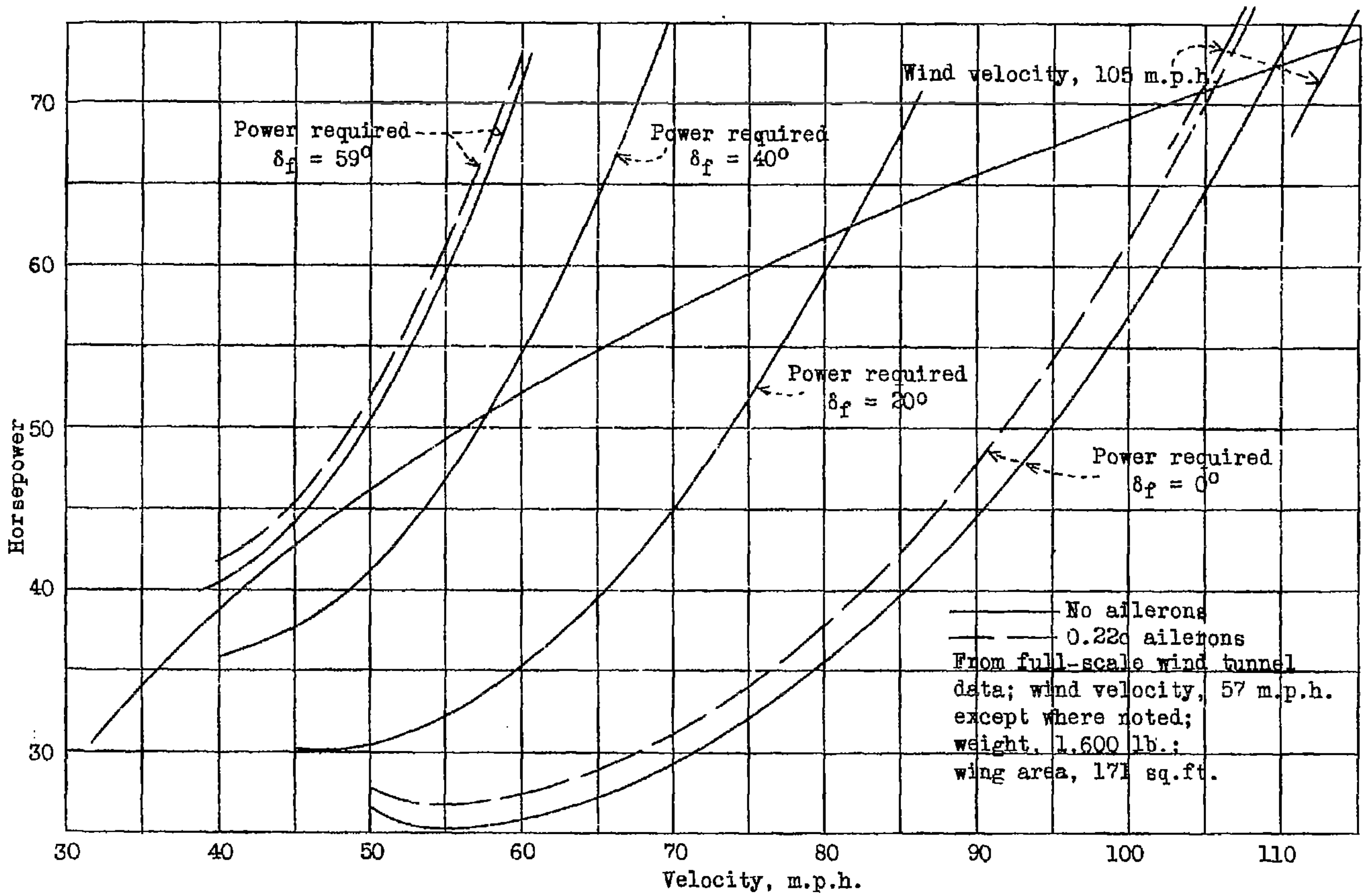


Figure 15.- Horsepower curves for Fairchild 22 airplane with Zap wing.

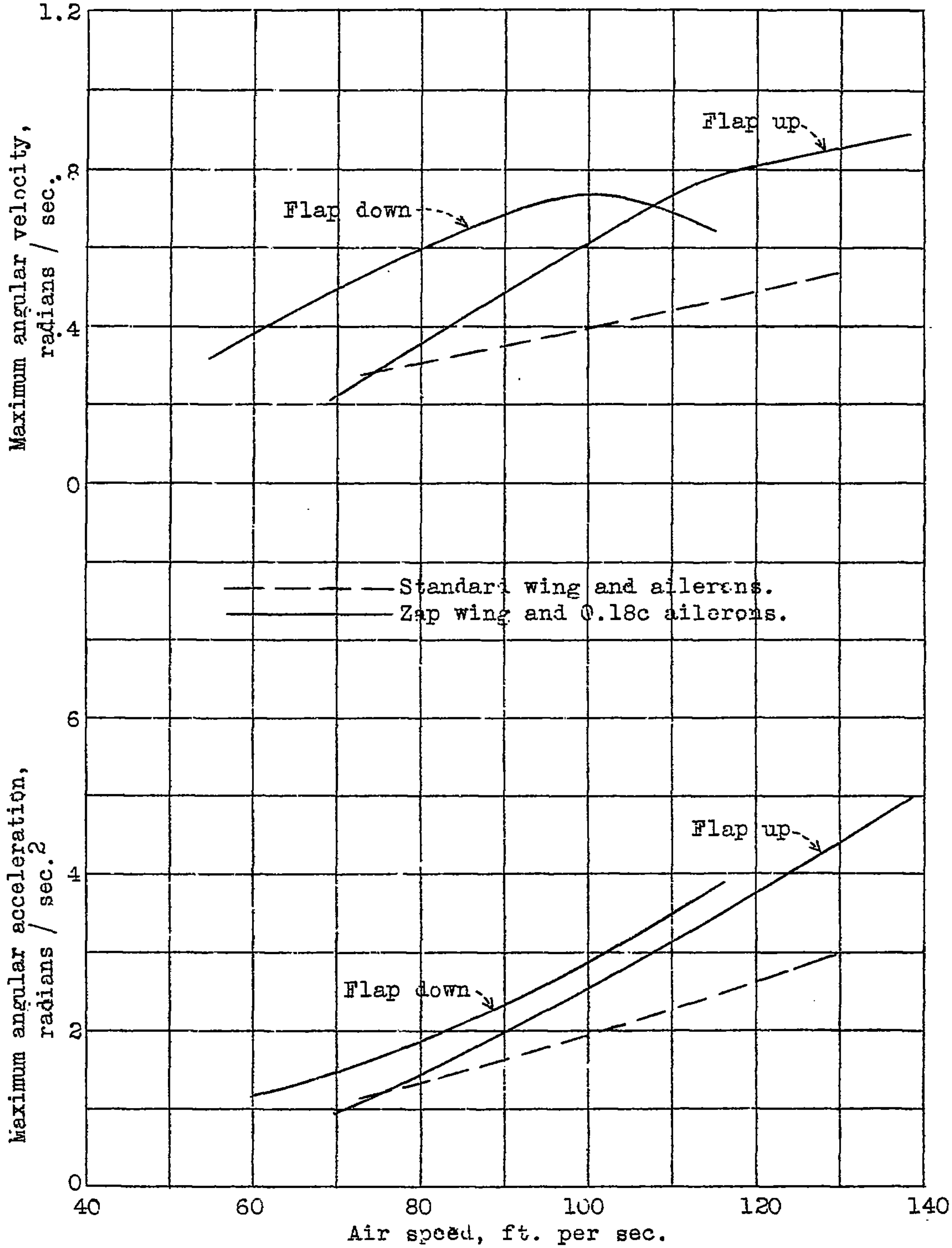


Figure 16.- Maximum rolling accelerations and velocities obtained with 0.18c Zap ailerons on Fairchild 22 airplane.

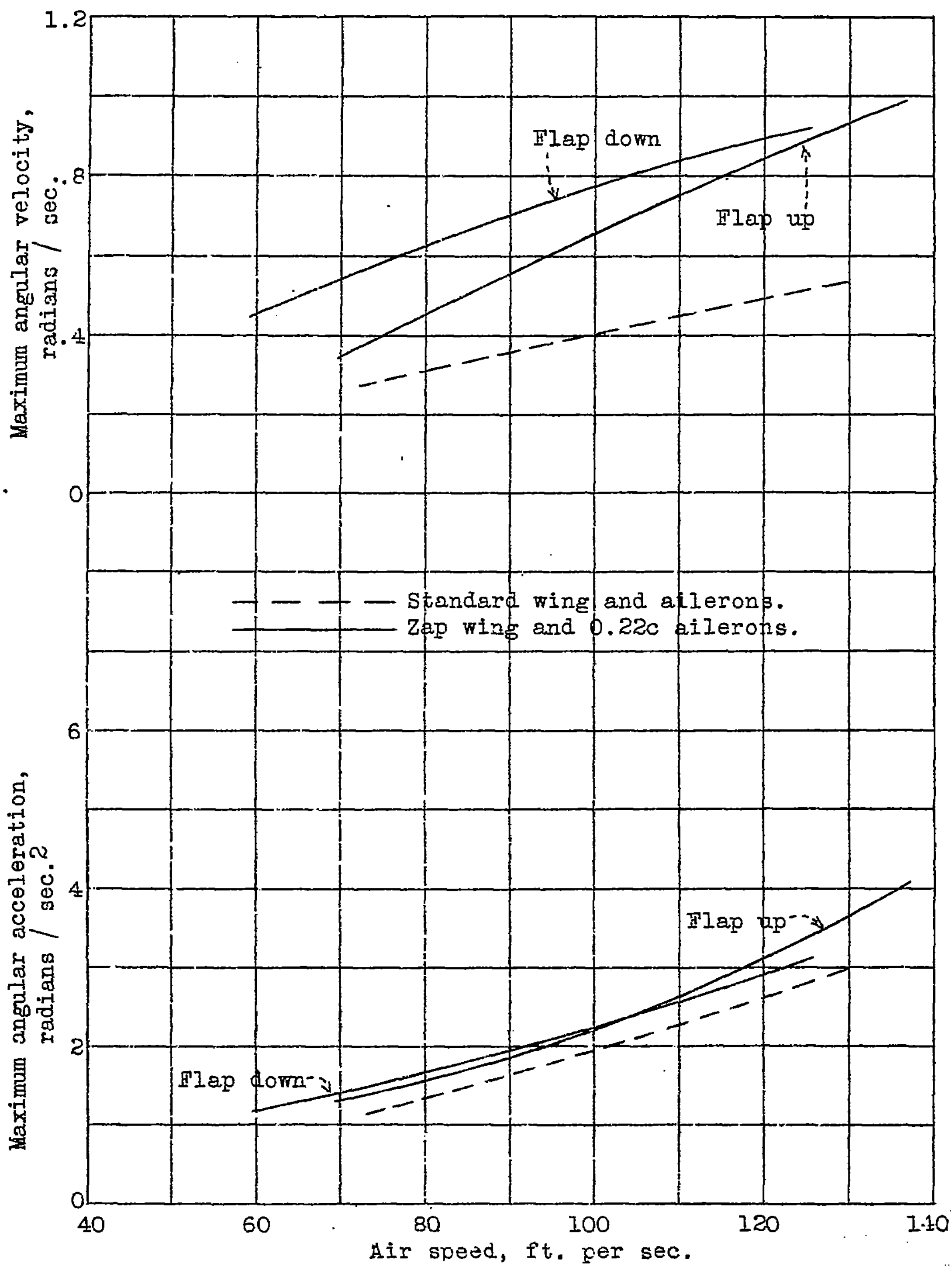


Figure 17.- Maximum rolling accelerations and velocities obtained with 0.22c Zap ailerons on Fairchild 22 airplane.

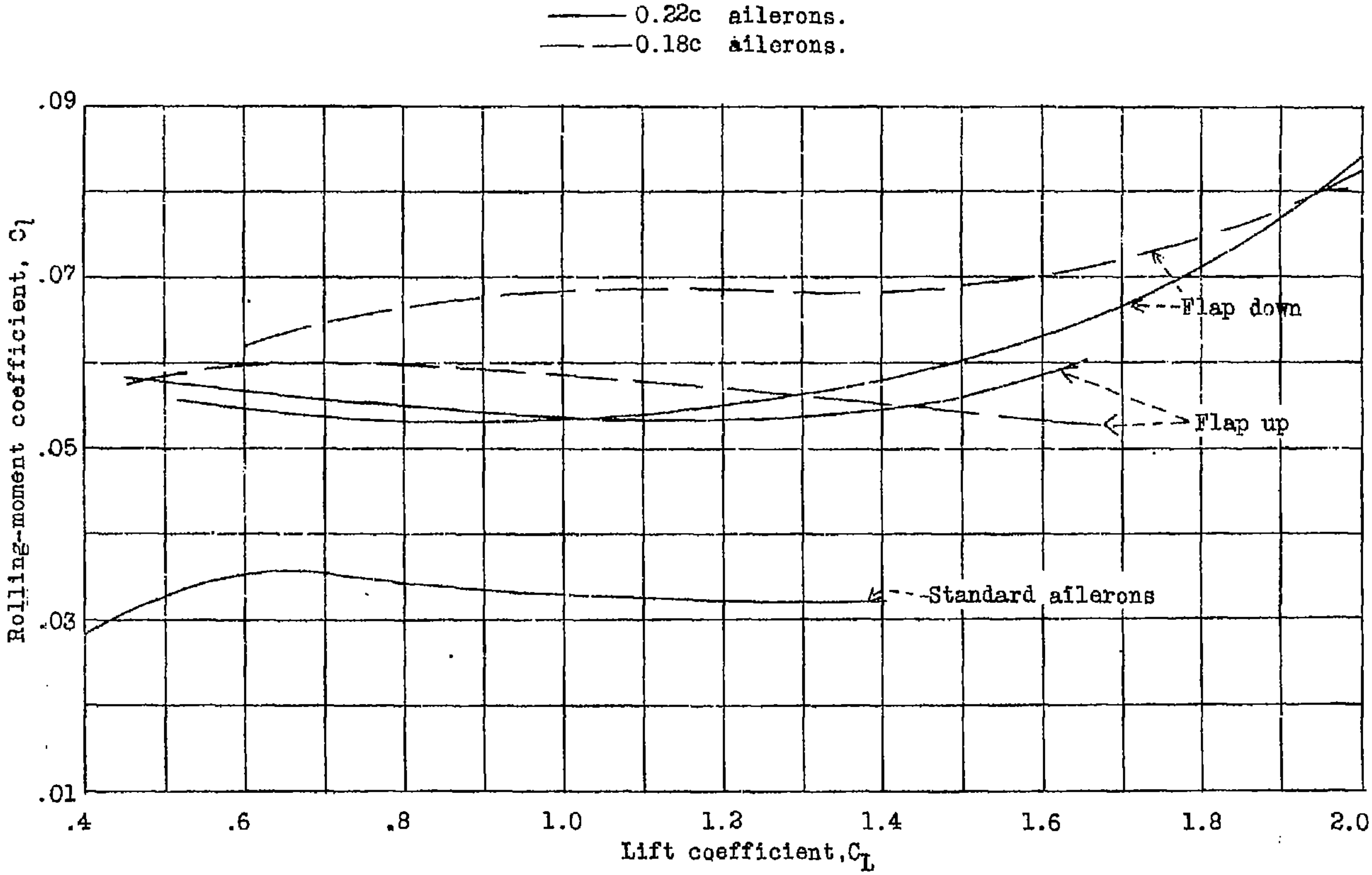


Figure 18.- Rolling-moment coefficients for Fairchild 22 airplane with Zap ailerons.

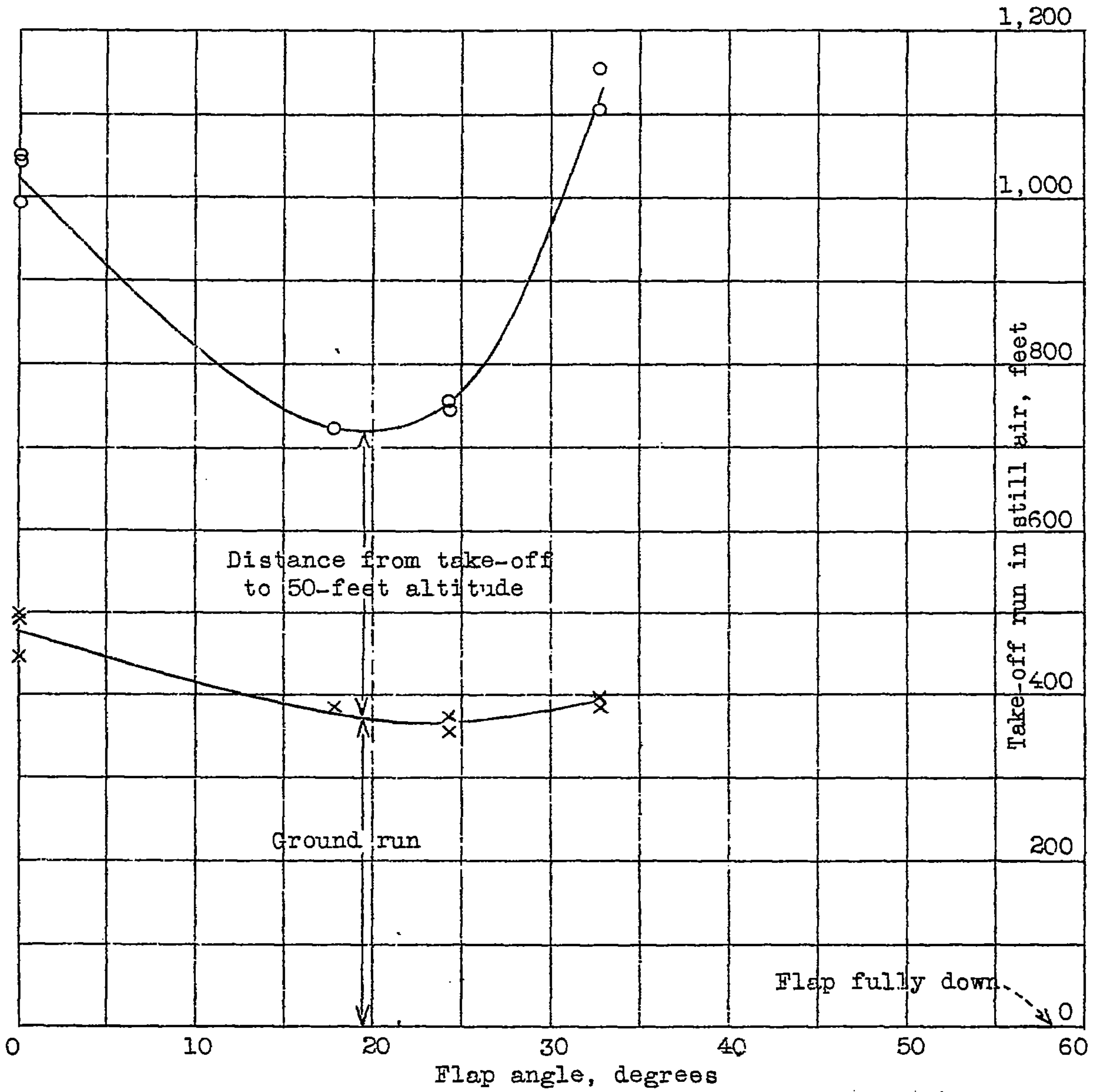


Figure 19.- Variation of take-off run with Zap flap setting on Fairchild 22 airplane.

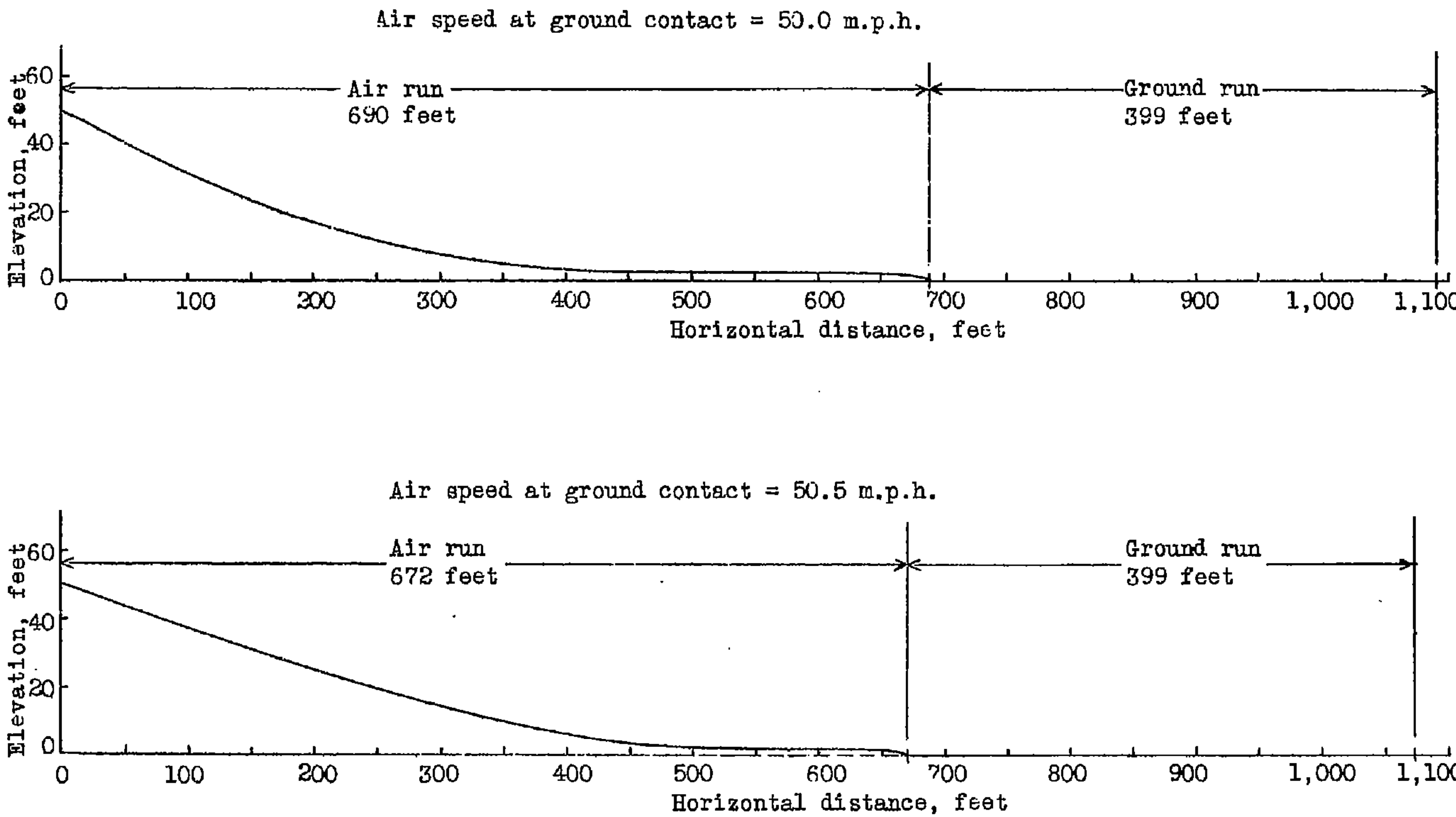
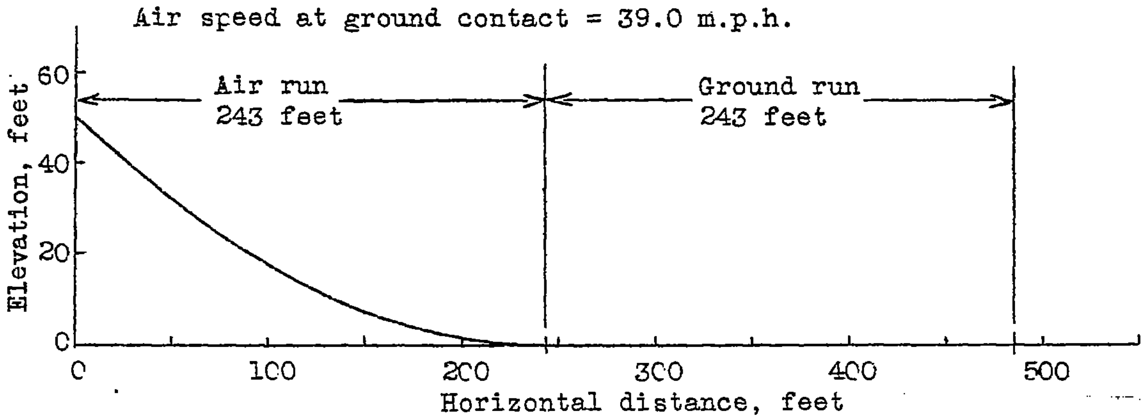
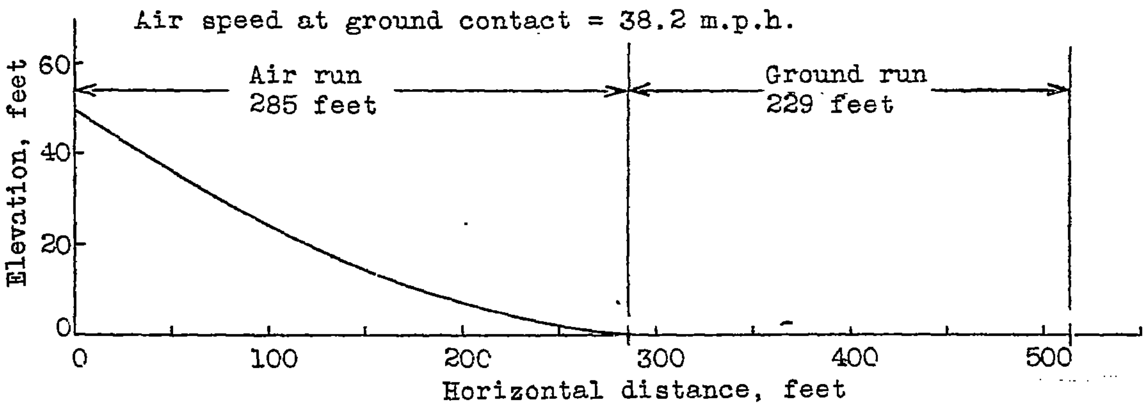


Figure 20.- Normal landings of the Fairchild 22 airplane with the Zap flap up.





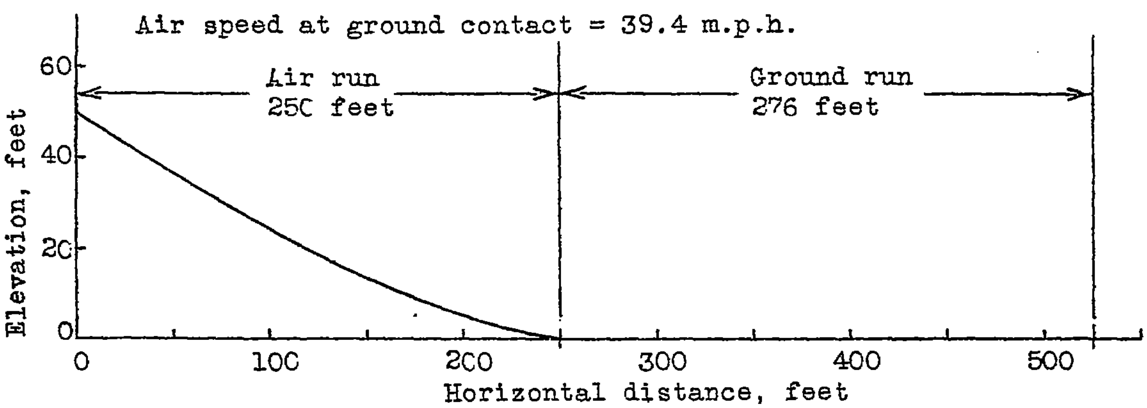


Figure 21.- Normal landings of the Fairchild 22 airplane with the Zap flap down.